

Raising Nuclear Thermal Propulsion (NTP) Technology Readiness Above 3

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NTP development is currently supported by the NASA program office “Advanced Exploration Systems”. The concept is a main propulsion option being considered for human missions to Mars in the 2030’s. Major NTP development took place in the 1960’s and 1970’s under the Rover/NERVA program. The technology had matured to TRL 6 and was preparing to go to TRL 7 with a prototype flight engine before the program was cancelled. Over the last 40 years, a variety of continuations started, but only lasted a few years each. The Rover/NERVA infrastructure is almost all gone. The only remains are a few pieces of hardware, final reports and a few who worked the Rover/NERVA.

Two types of nuclear fuel are being investigated to meet the current engine design specific impulse of 900 seconds compared to ~850 seconds demonstrated during Rover/NERVA. One is a continuation of composite fuel with new coatings to better control mid-band corrosion. The other type is a CERMET fuel made of Tungsten and UO₂. Both fuels are being made from Rover/NERVA lessons learned, but with slightly different recipes to increase fuel endurance at higher operating temperatures. The technology readiness level (TRL) of these current modified reactor fuels is ~TRL 3. To keep the development cost low and help mature the TRL level past 4 quickly, a few special non-nuclear test facilities have been made to test surrogate fuel, with depleted uranium, as coupons and full length elements. Both facilities utilize inductive heating and are licensed to handle depleted uranium. TRL 5 requires exposing the fuel to a nuclear environment and TRL 6 requires a prototype ground or flight engine system test. Currently, three different NTP ground test facility options are being investigated: exhaust scrubber, bore hole, and total exhaust containment. In parallel, a prototype flight demonstration test is also being studied.

The first human mission to Mars in the 2030’s is currently 2033. For an advanced propulsion concept to be seriously considered for use, the engine development plans need to show it is feasible and affordable to reach TRL 8 by 2027 and can be qualified for human mission use.